

# Description

## [Motor Protector]

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The following is based on and claims priority to Provisional Application serial number 60/503,785, filed September 17, 2003.

### BACKGROUND OF INVENTION

[0002] In a variety of wellbore environments, electric submersible pumping systems are used to lift fluids from a subterranean location. Although electric submersible pumping systems can utilize a wide variety of components, examples of basic components comprise a submersible pump, a submersible motor and a motor protector. The submersible motor powers the submersible pump, and the motor protector seals the submersible motor from well fluid. The motor protector also balances the internal motor oil pressure with external pressure.

[0003] Motor protectors often are designed with a labyrinth system and/or an elastomeric bag system. The labyrinth sys-

tem uses the difference in specific gravity between the well fluid and internal motor oil to maintain separation between the fluids. The elastomeric bag system relies on an elastomeric bag to physically isolate the motor oil from the well fluid while balancing internal and external pressures. Additionally, motor protectors often have an internal shaft that transmits power from the submersible motor to the submersible pump. The shaft is mounted in journal bearings positioned in the motor protector.

[0004] Such protectors function well in many environments. However, in abrasive environments, the runlife of the motor protector can be detrimentally affected. The abrasive sand causes wear in motor protector components, such as the journal bearings. Attempts have been made to increase runlife by populating the motor protector with journal bearings made from extremely hard materials to reduce wear caused by the abrasive sand.

## **SUMMARY OF INVENTION**

[0005] In general, the present invention relates to a motor protector for use in an electric submersible pumping system. The motor protector is designed to seal a submersible motor from well fluid and to keep the motor oil pressure generally balanced with external pressure. However, the

motor protector also is designed with a sand exclusion mechanism to reduce the effects of sand on protector runlife.

#### **BRIEF DESCRIPTION OF DRAWINGS**

- [0006] Certain embodiments of the invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:
- [0007] Figure 1 is a front elevation view of an electric submersible pumping system disclosed in a wellbore, according to an embodiment of the present invention;
- [0008] Figure 2 is a cross-sectional view taken generally along an axis of the motor protector illustrated in Figure 1, according to an embodiment of the present invention;
- [0009] Figure 3 is an enlarged view of an upper portion of the motor protector illustrated in Figure 2;
- [0010] Figure 4 is an orthogonal view of a bearing and lock ring embodiment that can be used with the motor protector illustrated in Figures 2 and 3;
- [0011] Figure 5 is an orthogonal view of a sleeve and lock ring embodiment that can be used with the motor protector illustrated in Figures 2 and 3;
- [0012] Figure 6 is a schematic illustration of an elastomeric bag

that can be used with the motor protector illustrated in Figures 2 and 3.

#### **DETAILED DESCRIPTION**

[0013] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those of ordinary skill in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0014] The present invention generally relates to a system and method for reducing detrimental effects of sand on motor protectors. The system and method are useful with, for example, a variety of downhole production systems, such as electric submersible pumping systems. However, the devices and methods of the present invention are not limited to use in the specific applications that are described herein.

[0015] Referring generally to Figure 1, an example of a pumping system 10, such as an electric submersible pumping system, is illustrated according to an embodiment of the present invention. Pumping system 10 may comprise a variety of components depending on the particular appli-

cation or environment in which it is used. In this example, however, pumping system 10 includes a submersible pump 12, a submersible motor 14 and a motor protector 16.

[0016] Pumping system 10 is designed for deployment in a well 18 within a geological formation 20 containing desirable production fluids, such as water or petroleum. A wellbore 22 typically is drilled and lined with a wellbore casing 24. Wellbore casing 24 includes a plurality of openings or perforations 26 through which production fluids flow from formation 20 into wellbore 22.

[0017] Pumping system 10 is deployed in wellbore 22 by a deployment system 28 that may have a variety of forms and configurations. For example, deployment system 28 may comprise tubing, such as coil tubing or production tubing, connected to pump 12 by a connector 32. Power is provided to submersible motor 14 via a power cable 34. Motor 14, in turn, powers pump 12 which draws production fluid in through a pump intake 36, and pumps the production fluid to the surface via tubing 30.

[0018] It should be noted that the illustrated submersible pumping system 10 is merely an example. Other components can be added to this system and other deployment sys-

tems may be implemented. Additionally, the production fluids may be pumped to the surface through tubing 30 or through the annulus formed between deployment system 28 and wellbore casing 24. In any of the many potential configurations of submersible pumping system 10, motor protector 16 is used to seal the submersible motor 14 from well fluid in wellbore 22 and to generally balance the internal pressure within submersible motor 14 with the external pressure in wellbore 22.

[0019] Referring generally to Figure 2, an embodiment of motor protector 16 is illustrated in greater detail. Motor protector 16 comprises an outer housing 38 within which a drive shaft 40 is rotatably mounted via a plurality of bearings 42, such as journal bearings. Outer housing 38 may be formed of one or more housing components. Also, the motor protector 16 is divided into a plurality of sections, including a head section 44 disposed generally at an upper end of the protector. An additional section (or sections) is disposed below head section 44 and functions as a fluid separation section to separate wellbore fluid that may enter head section 44 from internal motor oil used to lubricate submersible motor 14. The sections also facilitate balancing of internal and external pressures. In the

embodiment illustrated, a labyrinth section 46 is disposed below head section 44, and a pair of elastomeric bag sections 48 are disposed below labyrinth section 46.

[0020] Labyrinth section 46 comprises a labyrinth 50 that uses the difference in specific gravity of the well fluid and the internal motor oil to maintain separation between the internal motor oil and the well fluid. Each bag section uses an elastomeric bag 52 to physically isolate the internal motor oil from the well fluid. It should be noted that the motor protector sections may comprise a variety of section types. For example, the motor protector may comprise one or more labyrinth sections, one or more elastomeric bag sections, combinations of labyrinth and bag sections as well as other separation systems. A series of fluid ports or channels 54 connect each section with the next sequential section. In the embodiment illustrated, a port 54 is disposed between head section 44 and labyrinth section 46, between labyrinth section 46 and the next sequential bag section 48, between bag sections 48 and between the final bag section 48 and a lower end 56 of motor protector 16.

[0021] Motor protector 16 may comprise a variety of additional features. For example, a thrust bearing 58 may be de-

played proximate lower end 56 to absorb axial loads placed on shaft 40 by the pumping action of submersible pump 12. The protector also may comprise an outward relief mechanism 60, such as an outward relief valve. The outward relief valve releases excessive internal pressure that may build up during, for example, the heating cycle that occurs with startup of electric submersible pumping system 10. Motor protector 16 also may comprise an inward relief mechanism 62, such as an inward relief valve. The inward relief valve relieves excessive negative pressure within the motor protector. For example, a variety of situations, such as system cooldown, can create substantial internal pressure drops, i.e. negative pressure, within the motor protector. Inward relief mechanism 62 alleviates the excessive negative pressure by, for example, releasing external fluid into the motor protector to reduce or avoid mechanical damage to the system caused by this excessive negative pressure.

[0022] The motor protector 16 also comprises an abrasives exclusion mechanism 64 to reduce motor protector wear. Abrasives exclusion mechanism 64 is disposed within a head section chamber 66 into which drive shaft 40 extends. Head section chamber 66 is formed within outer



housing 38 and is defined at its bottom by a lower end floor or platform 68 of head section 44.

[0023] Abrasives exclusion mechanism 64 is designed to limit the effects of abrasives, such as particulates, e.g. sand, scale, debris and various other abrasives that can enter head section chamber 66 with the well fluid. The abrasive quality of such materials can damage the head section, particularly head section components such as seals and head section journal bearings. Abrasives that are able to damage the head section also may gain access to other motor protector components as the sand, or other abrasive material, works its way toward the thrust bearing 58 and submersible motor 14. A damaged head section also may increase the vibration of drive shaft 40 and cause further system damage. It should be noted that abrasives exclusion mechanism 64 also may be designed to limit movement of abrasives into subsequent motor protector sections beneath the head section, as described more fully below.

[0024] Abrasives exclusion mechanism 64 comprises one or more components or component orientations that limit contact between the abrasive material and susceptible motor protector components, thereby reducing wear and

increasing runlife. Referring generally to Figure 3, a specific embodiment of the exclusion mechanism 64 is illustrated.

[0025] As illustrated, mechanism 64 may comprise a raised shaft seal 70 having a raised seal face. Shaft seal 70 is located at an elevated position within head section chamber 66. In other words, shaft seal 70 is raised above the lower end floor 68 so that any abrasives accumulating along floor 68 do not destroy or create excessive wear on shaft seal 70 during operation. Thus, components disposed along shaft 40 remain better protected from abrasives entering head section 44.

[0026] Abrasives exclusion mechanism 64 also may comprise one or more drain holes 72 positioned to reduce the possible accumulation of abrasive material in head chamber 44. One or more holes may be formed through outer housing 38 to enable the outflow of, for example, sand from head section chamber 66 to the external environment surrounding motor protector 16. In the embodiment illustrated, a plurality of drain holes 72 are formed generally radially through outer housing 38 proximate a lower end of head section 44. For example, the drain holes may be formed just above the lower end floor 68.

[0027] A shroud 74 also may be used to block the movement of sand towards shaft seal 70, upper journal bearing 42 and other components below. Shroud 74 is a stationary shroud positioned over the upper bearing 42 and shaft seal 70. For example, shroud 74 may be mounted to a seal body 76 or other boss within head section chamber 66. Shroud 74 includes an upper opening 78 through which shaft 40 extends. Thus, shroud 74 remains stationary with respect to head section 44 during rotation of shaft 40. Shroud 74 may be made out of metal sheet material or other materials able to provide a barrier that blocks the flow of abrasive particles. Thus, sand, or other abrasives, within head section chamber 66 does not contact shaft seal 70, upper journal bearing 42 or other components disposed below the upper journal bearing 42.

[0028] A rotatable shroud 80 may be deployed above stationary shroud 74 to prevent the movement of sand particles through upper opening 78 from a location above shroud 74 and into proximity with shaft seal 70. Rotatable shroud 80 functions as an umbrella-like component to disburse particles away from upper opening 78. In the embodiment illustrated, rotatable shroud 80 is attached to shaft 40 and rotates with the shaft. The rotation of shroud 80 along

stationary shroud 74 causes a rotating movement of fluid along the space between the stationary shroud 74 and the rotatable shroud 80. This moving fluid creates a centrifuge effect that further limits contact between abrasive particles and shaft seal 70 or journal bearing 42. Alternatively, a seal may be created between shroud 74 and shroud 80. Furthermore, a variety of materials can be used to construct shroud 80, and the component may be attached to shaft 40 by a variety of mechanisms, including snap rings, collars, fasteners, etc.

[0029] As discussed above, a port 54 enables communication of fluid between head section chamber 66 and the next adjacent fluid separation section, such as labyrinth section 46. To prevent the flow of abrasives from head section chamber 66 into successive sections, exclusion mechanism 64 also may comprise a stand tube 82 connected to the port 54 and extending upwardly into head section chamber 66. Thus, any particulates accumulating along lower end floor 68 are not allowed to fall through port 54 into adjacent motor protector sections. Further precautions may be taken against abrasives entering port 54 by bending the stand tube 82 or providing the stand tube with a bent section 84. Alternatively or additionally, stand

tube 82 may be provided with a cap 85 (shown in dashed lines), a filter 86 (shown in dashed lines), a tortuous path 87 (shown in dashed lines) or other sand blocking mechanisms.

[0030] Motor protector 16 also may comprise a vent passageway 88 for venting air from head section chamber 66 during, for example, oil-filling procedures. As motor oil is poured into motor protector 16 and submersible motor 14, escaping air is vented through passageway 88. In the embodiment illustrated, vent passageway 88 is disposed through shaft 40. For example, passageway 88 may comprise a radial passage 90 extending from a radial exterior of the shaft to an axial passageway 92. Axial passageway 92 routes escaping air upwardly through shaft 40 and through an outlet or valve 94 disposed at the top end of shaft 40.

[0031] Referring generally to Figures 4 and 5, one or more journal bearings 42 may be formed as keyless journal bearings. For example, the upper two journal bearings, illustrated in Figure 3, may be formed as keyless bearings. The keyless journal bearings are able to substantially reduce the stress concentration otherwise caused by conventional key ways or notches. In the embodiment illus-

trated in Figure 3, at least two keyless journal bearings 42 are used in a top seal body 96 to improve the system stability. The use of two or more bearings in a single body renders the overall system more robust and reduces tolerance stacking.

[0032] In Figure 4, an example of a bearing portion 98 and a lock ring 100 are illustrated. Similarly, in Figure 5, an example of a sleeve 102 and lock ring 104 are illustrated. In both cases, the lock rings 100, 104 create a mating "wavy" interface with the corresponding bearing portion 98 and sleeve 102 for load transfer. In this example, each lock ring comprises one or more protuberances 106 that engage corresponding recesses 108 on the bearing and sleeve, respectively. The bearing components may be made from hard materials, such as ceramic, carbide or cermet materials. This keyless design greatly reduces stress concentrations which, in turn, helps reduce cracking or other wear on the bearing and/or sleeve.

[0033] Motor protector 16 also may utilize reinforced bags, as illustrated in Figure 6, in bag sections 48. The reinforced bags can be useful in, for example, high temperature applications. In one embodiment, each bag 52 comprises a polymer layer 110 and a reinforced layer 112, such as a

perfluoroelastomer or fiber-reinforced layer. In the example illustrated, reinforced layer 112 comprises a fiber layer that is disposed between polymer layers 110. This multi-layer, composite approach provides a strong bag 52 able to withstand high temperatures or other adverse conditions.

[0034] Although only a few embodiments of the present invention have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this invention. Accordingly, such modifications are intended to be included within the scope of this invention as defined in the claims.